

TOPIC OF THIS TALK:



*Multidimensional, multi-slice
and multi-scale MRI for quality
evaluation in horticultural
products*



NUCLEAR IMAGING OF FOOD PRODUCTS



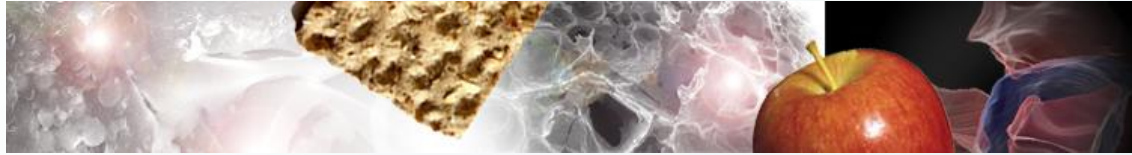
LPF_TAGRALIA



INSIDEfOOD

Pilar Barreiro

ABOUT INSIDEFOOD



InsideFood explicitly aims at measuring food microstructure, the spatial distribution of food components within foods, with state of the art tomographic, spectroscopic and texture measurement techniques including X-ray micro- and nano CT, MRI, OCT, NMR, TRS and SRS, and acoustic emission.

Nutritional quality (sugar- and gluten-free cereal products), sensory quality (texture of all foods) and safety (foreign material detection in cereal products) are considered.

Online and inline techniques including NMR, MRI, TRS, SRS and X-ray imaging to visualise and monitor structure will be developed.





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Publications

General presentations

InsideFood [\[poster\]](#)

InsideFood [\[ppt 2011\]](#)

Newsletters

[\[Newsletter 1 2010\]](#)

[\[Newsletter 2 2011\]](#)

[\[Newsletter 3 2012\]](#)

Youtube

Journey to the center of an apple [\[movie clip\]](#)

Bubbles in sugar foam [\[movie clip\]](#)



BRIAN HILLS

IN MEMORIAM

When I heard the Learn'd Astronomer

WHEN I heard the learn'd astronomer;

*When the proofs, the figures, were ranged in
columns before me;*

*When I was shown the charts and the diagrams, to
add, divide, and measure them;*

*When I, sitting, heard the astronomer, where he
lectured with much applause in the lecture-room,*

How soon, unaccountable, I became tired and sick;

*Till rising and gliding out, I wander'd off by myself,
In the mystical moist night-air, and from time to
time,*

Look'd up in perfect silence at the stars.

Walt Whitman

¿What do we know about the structure of fruits?

- Vascular system of apple



K.U.Leuven (BE), SkyScan (BE), VSG (FR)

YouTube

Buscar

Explorar

Journey to the centre of an apple.wmv

KULMeBios

5 videos

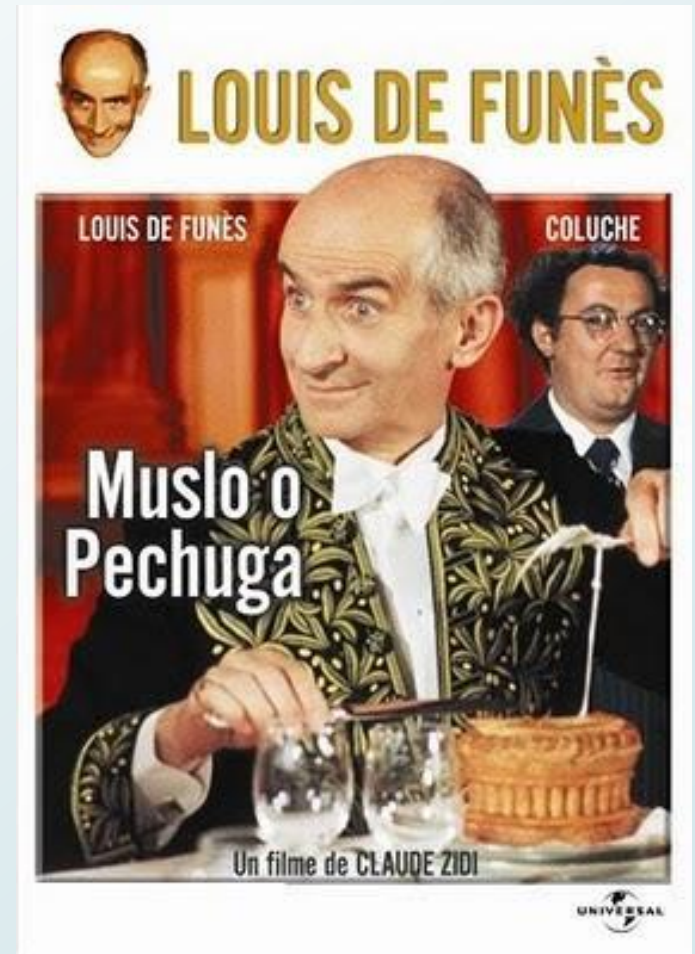
Suscribirse



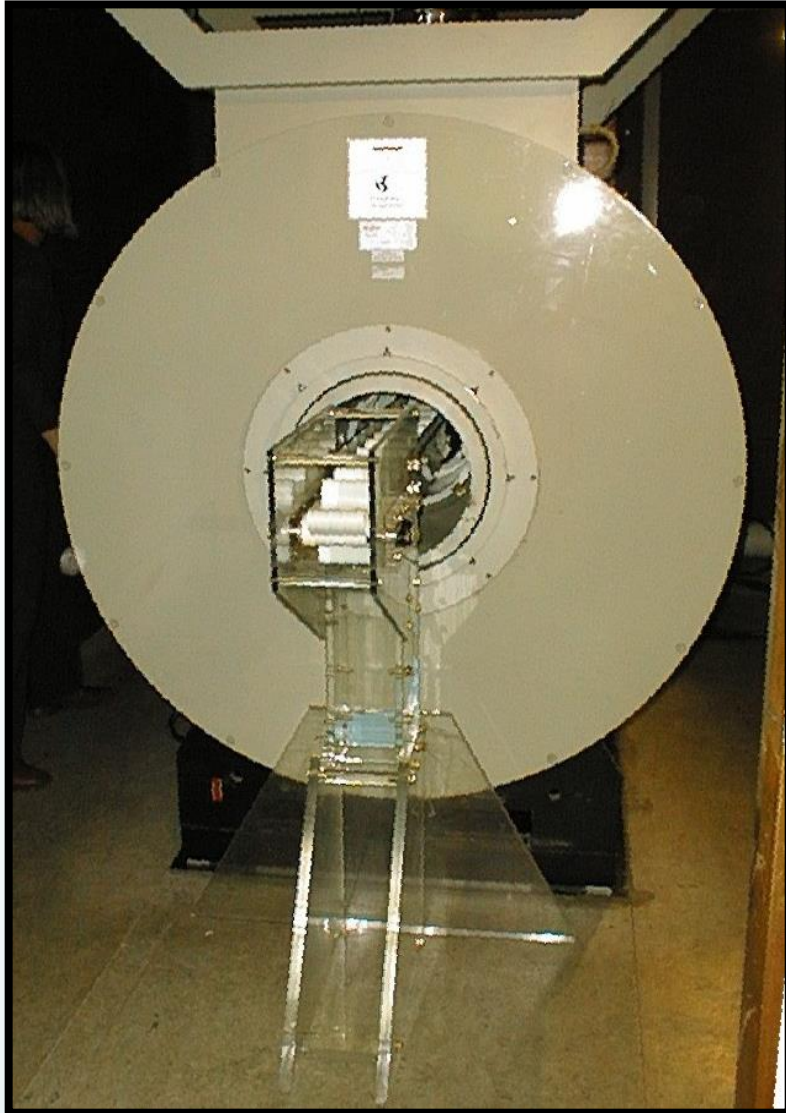
Reverse engineering of food



[Justin McGuirk](http://www.guardian.co.uk)
[guardian.co.uk](http://www.guardian.co.uk), Wednesday 15 September 2010 14.43 BST
[Article history](#)

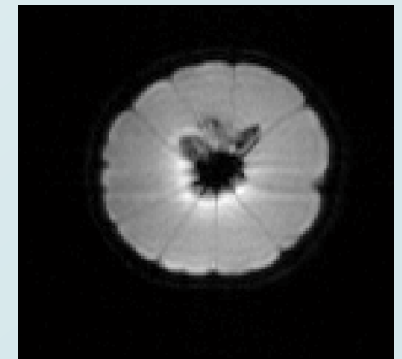
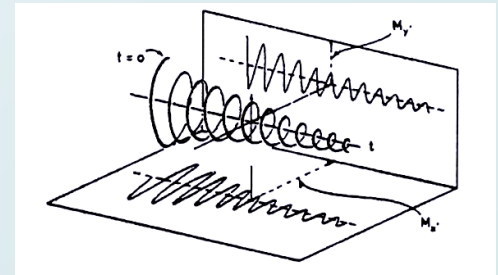
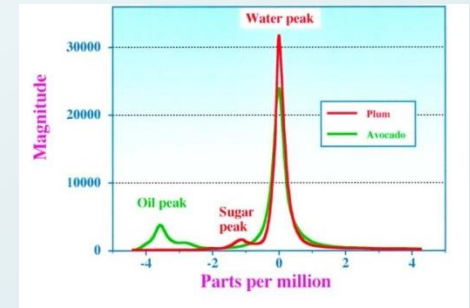


NMR as a multiscale multicomponent technique



Approaches

- Magnetic Resonance Spectroscopy (MRS)
- Magnetic Resonance Relaxometry (MRR)
- Magnetic Resonance Imaging (MRI)



Scalability of NMR

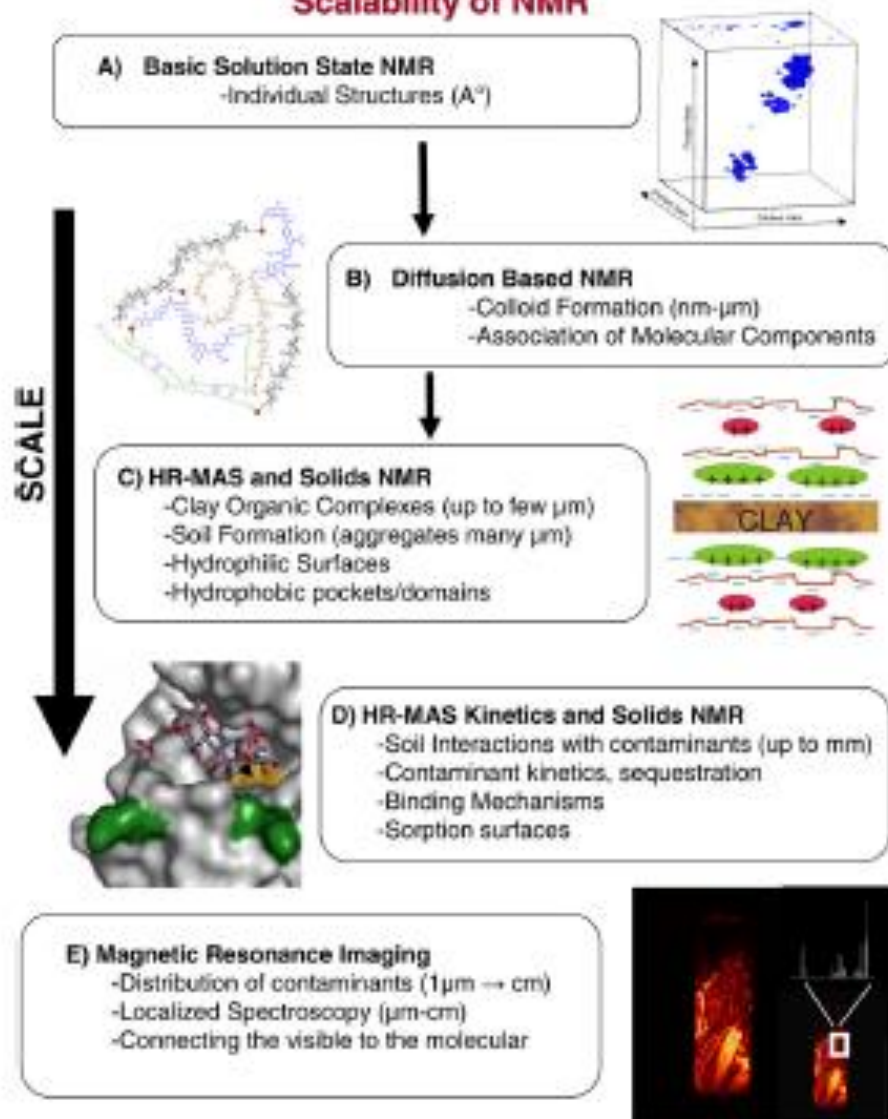


Fig. 2. A diagrammatic example demonstrating how NMR can be applied to connect the molecular level to the visual.

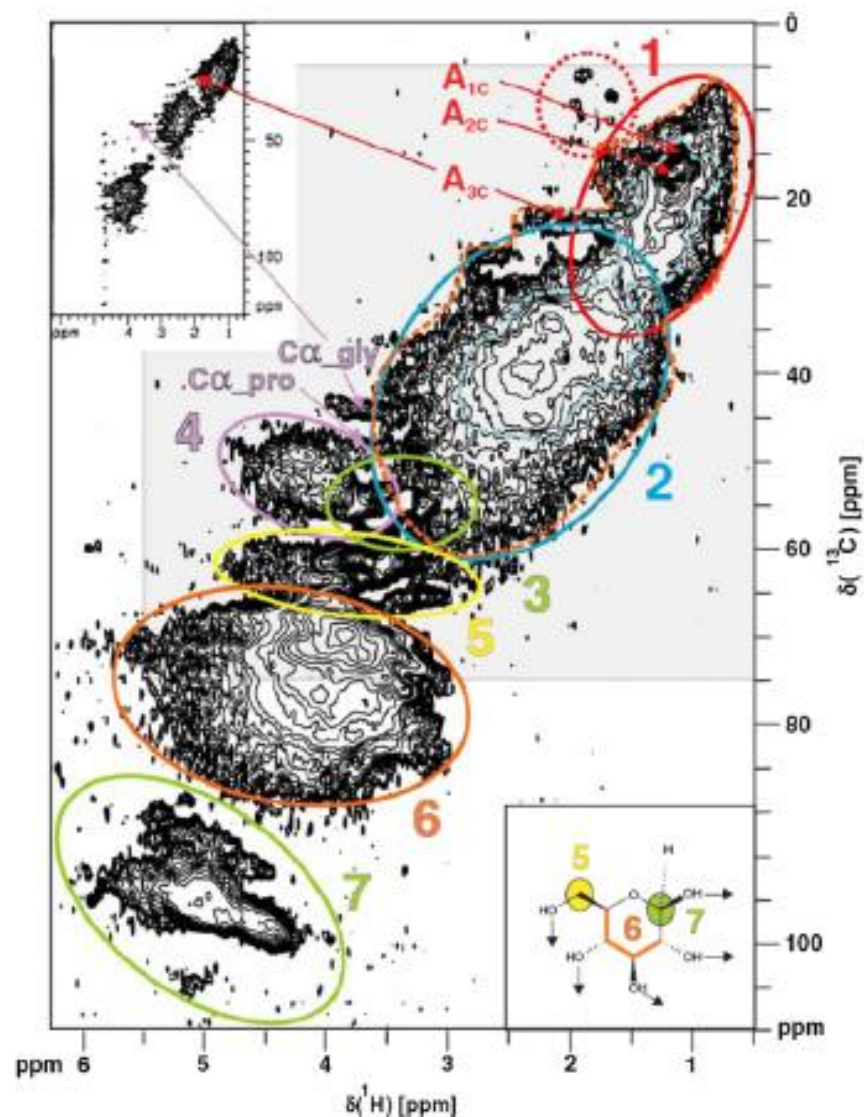
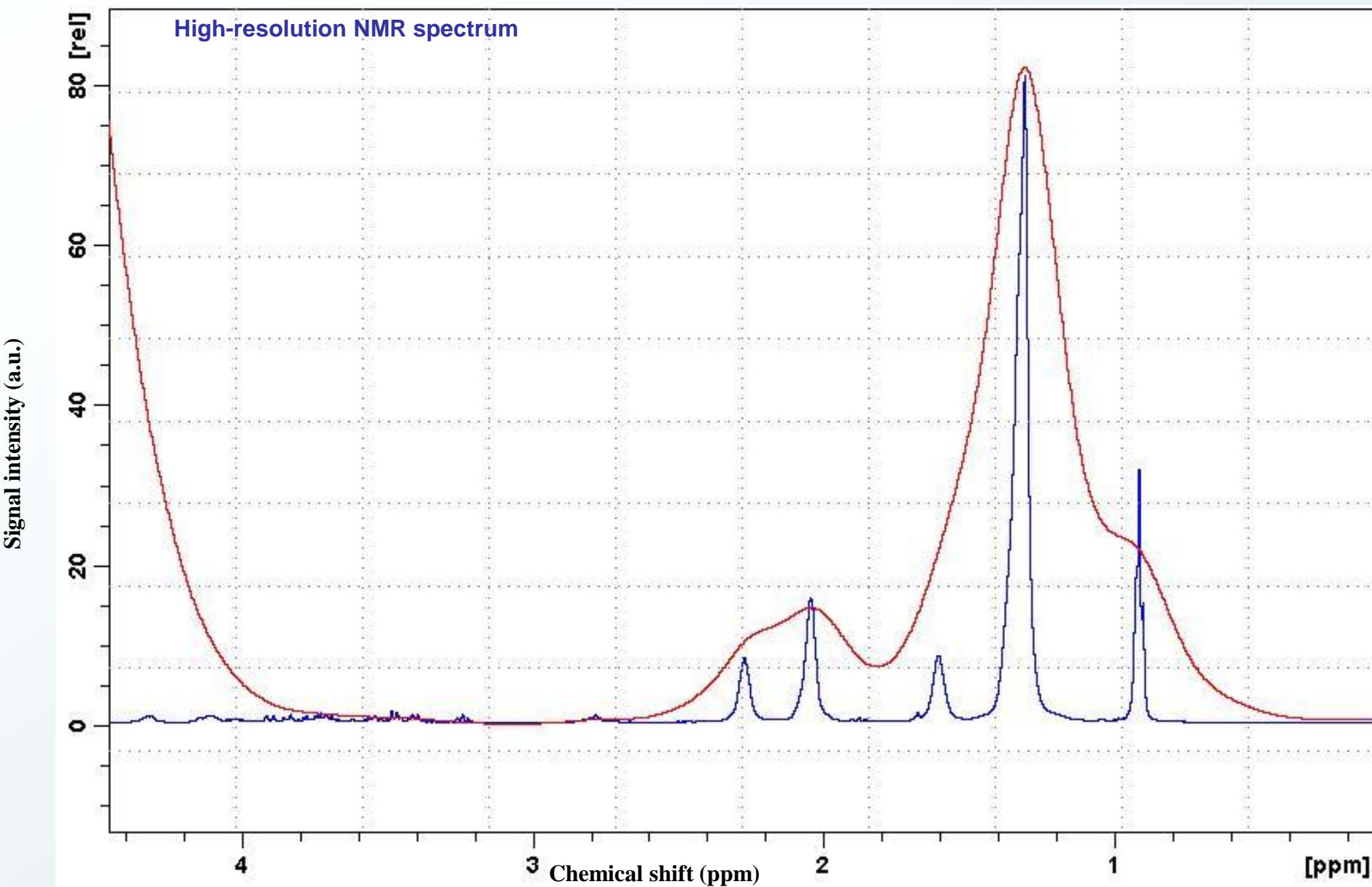


Fig. 32. Two dimensional ^1H - ^{13}C HSQC NMR spectra at 11.7 T of ultrafiltered dissolved organic matter isolated from Pacific Ocean water. The main assignments can be summarized as 1 = methyl bound to carbon and sulfur (dotted circle), and in the lower left corner, branched purely aliphatic CH pairs and polymethylene, 2 = methylene and methine cross-peaks without direct bonds to heteroatoms, 3 = low intensity cross-peaks from methoxyl, 4 = cross-peaks representative mainly of α -CH in proteins and vicinal dicarboxylic acids, 5 = carbohydrate methylene cross-peaks, 6 = carbohydrate methine cross-peaks, 7 = anomeric units in carbohydrates. A_{1C} = (poly)alanine- CH_3 ; A_{2C} = methylated carbohydrates; A_{3C} = N-acetyl carbohydrate. Reproduced from Ref. [130] with permission from Elsevier Science.

Low-resolution NMR spectrum

High-resolution NMR spectrum



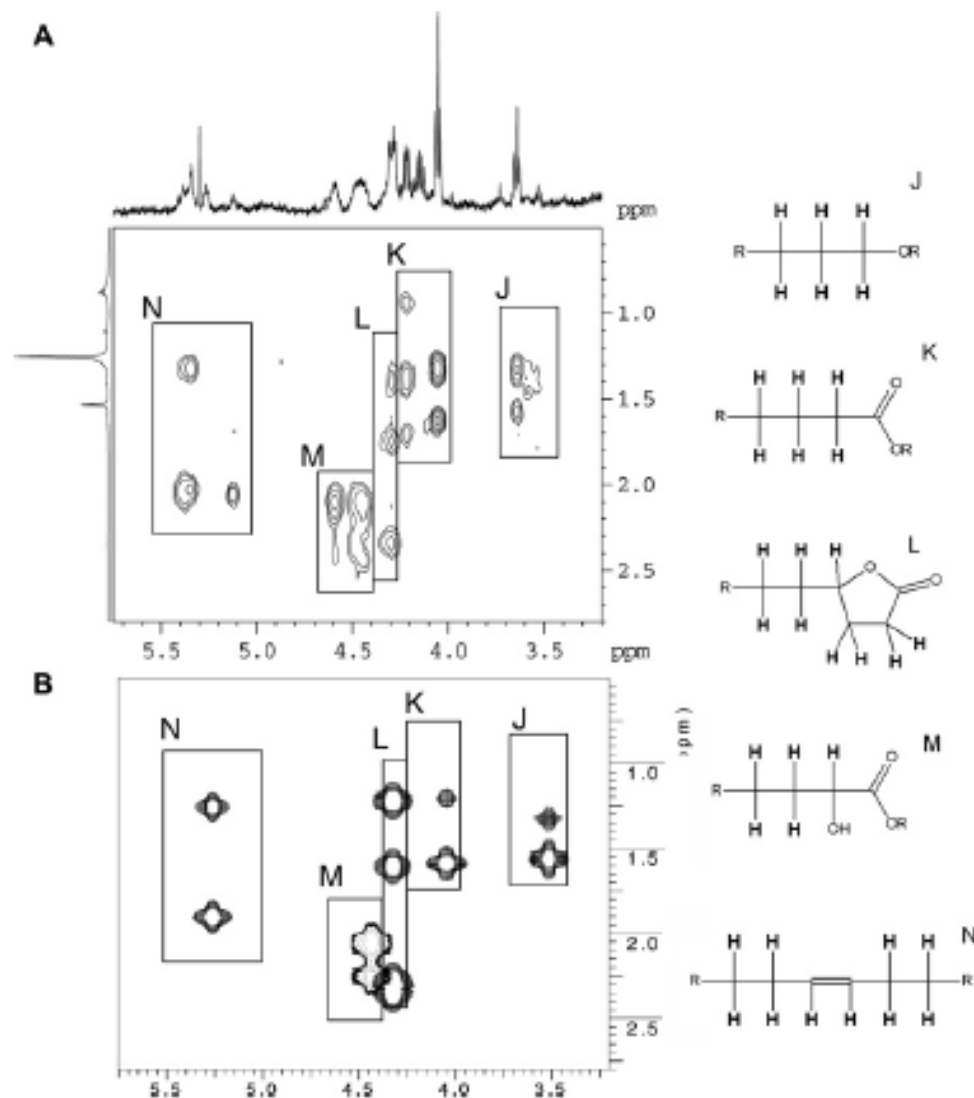
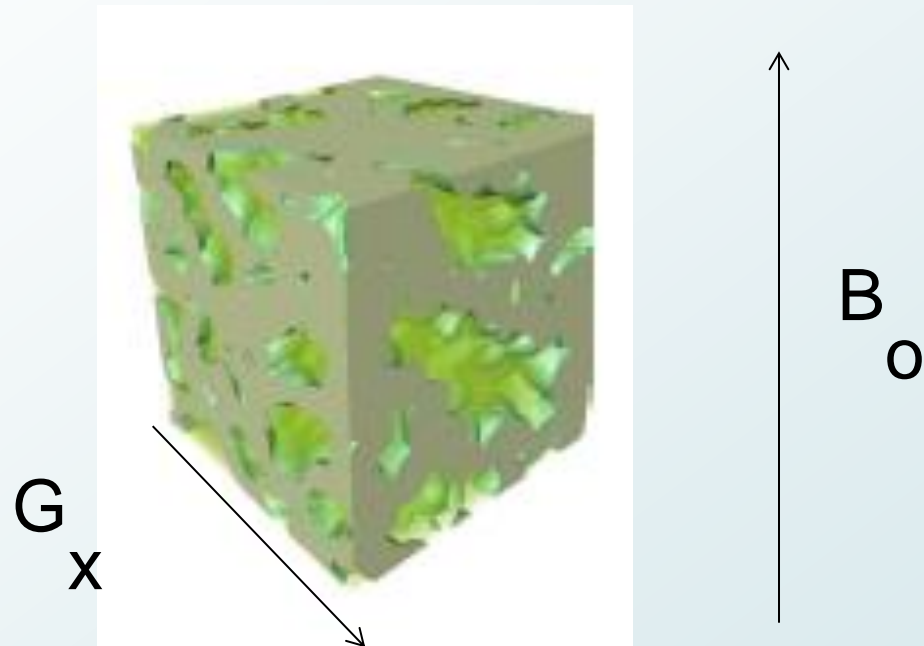


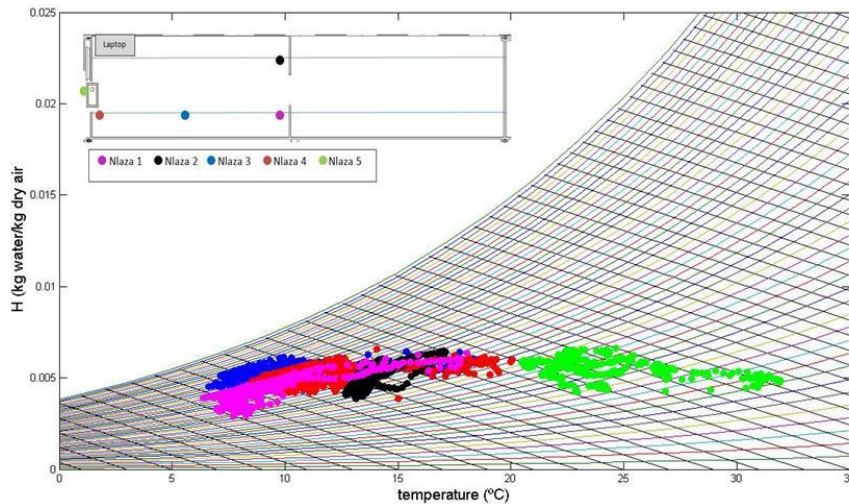
Fig. 35. An example of ^1H - ^1H TOCSY data recorded at 500 MHz and predicted 2D NMR spectra for components in the chloroform extract from urban atmospheric deposits. (A) Expanded region of the TOCSY spectrum for the d -chloroform extract (B) simulation of a TOCSY experiment for the assignments shown. Reproduced from Ref. [98] with permission from Elsevier Science.

How to use the information without dying



$$M(t) = e^{\frac{-t}{T_2}} \times e^{i\omega_0 t} \times e^{i\gamma G_x t} \times e^{-q^2 D \Delta} \times e^{i2\pi q v \Delta}$$

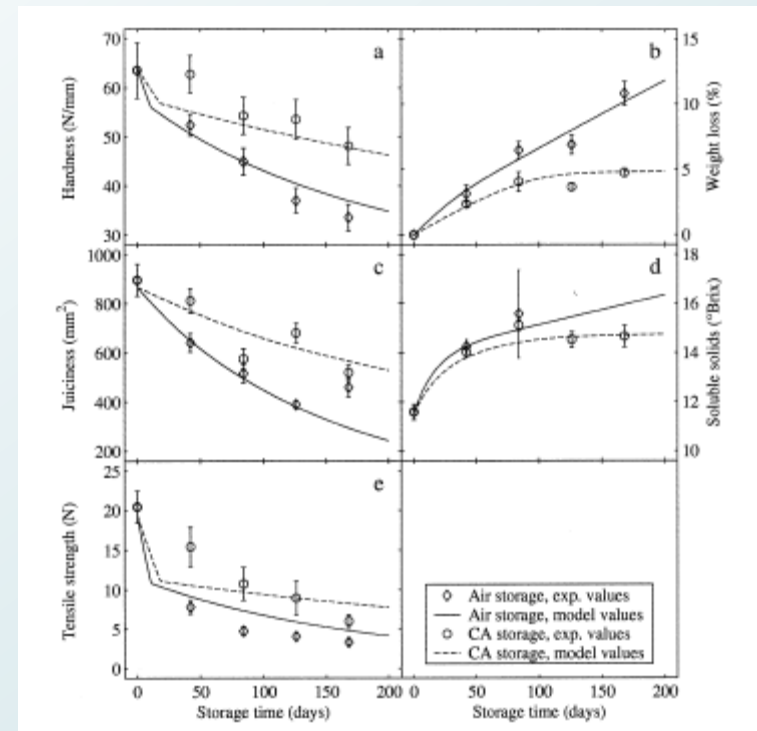
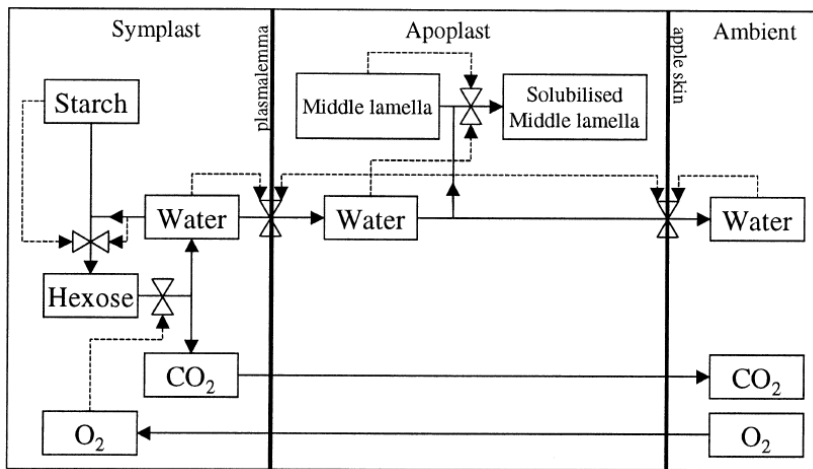
Water loss dynamics in a chemically stable food



García-Hierro y cols. 2010



Interaction between physical and biochemical processes

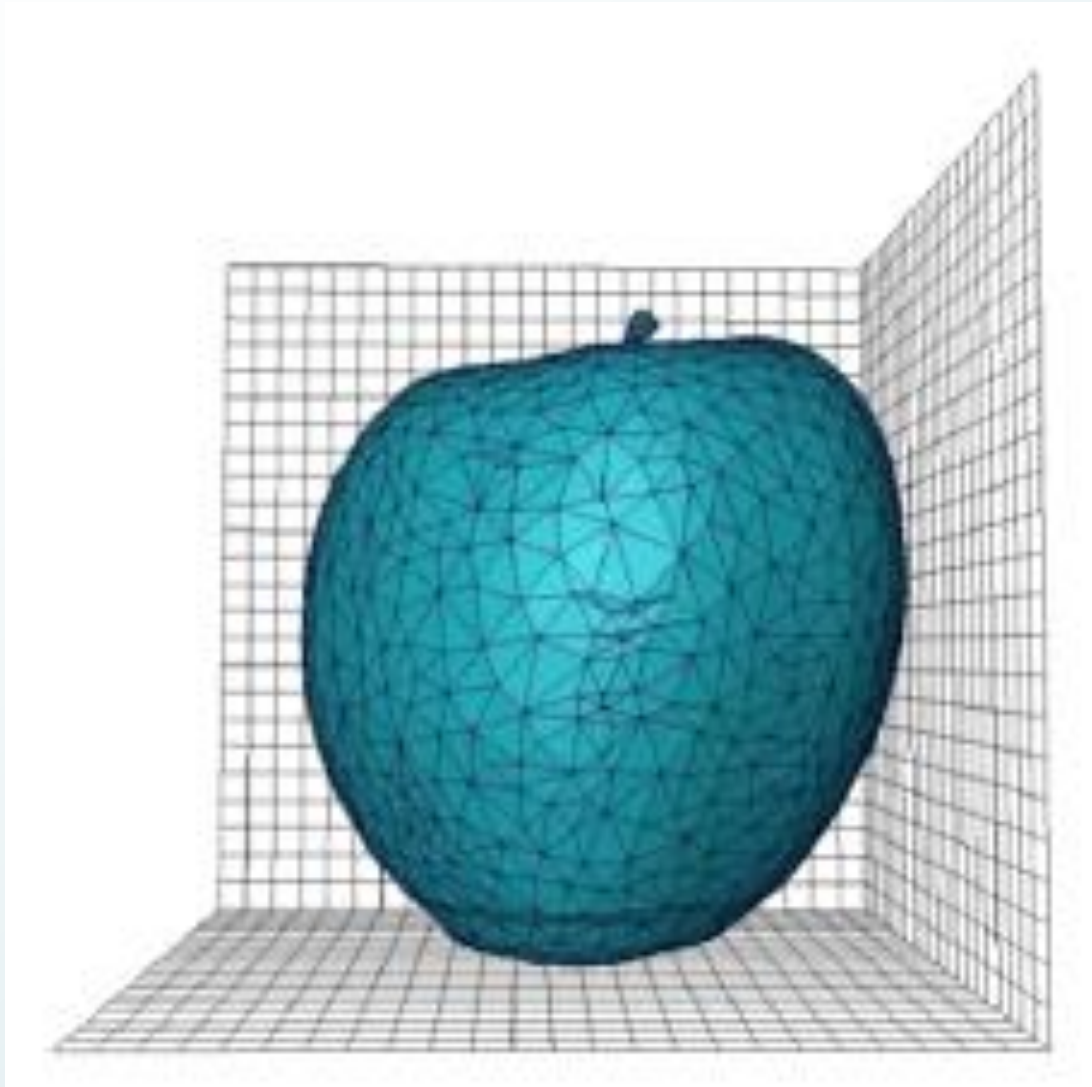


De Smedt et al., 2002

Gas diffusion

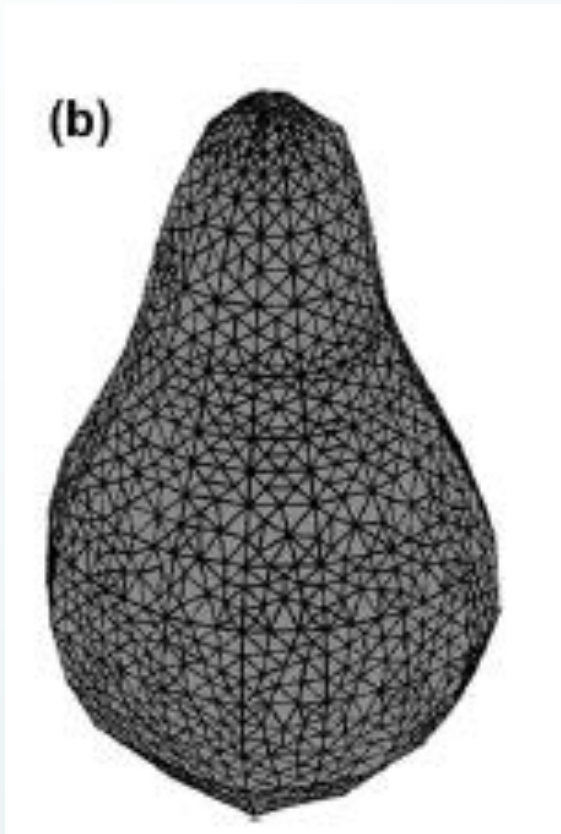


The importance of the mesh

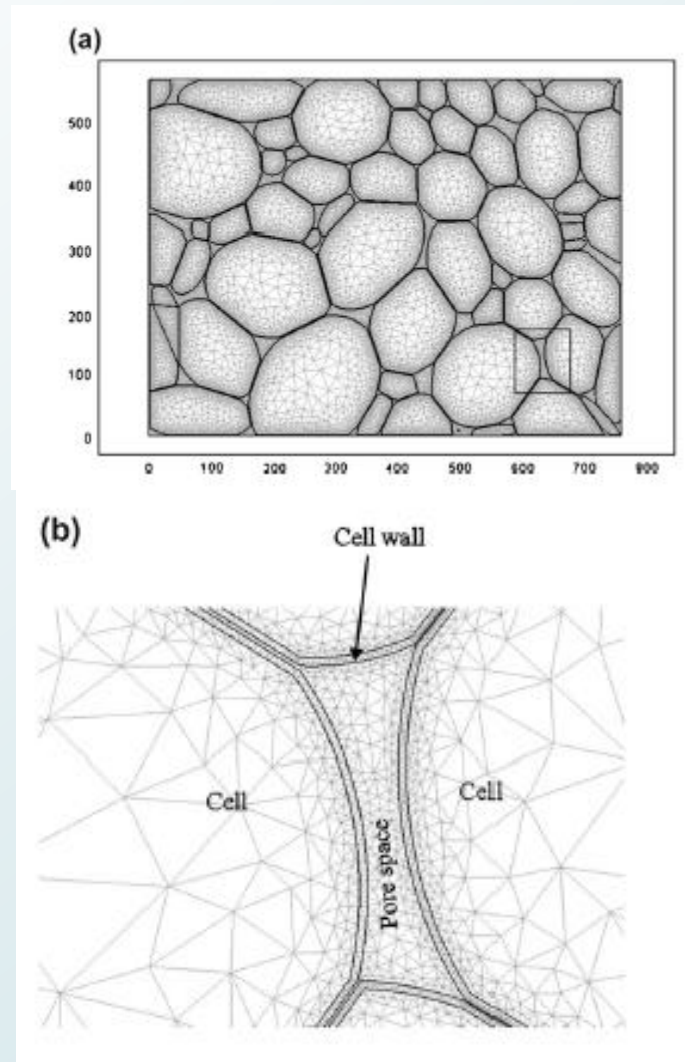


AVIZO SOFTWARE

Multi-scale modelling

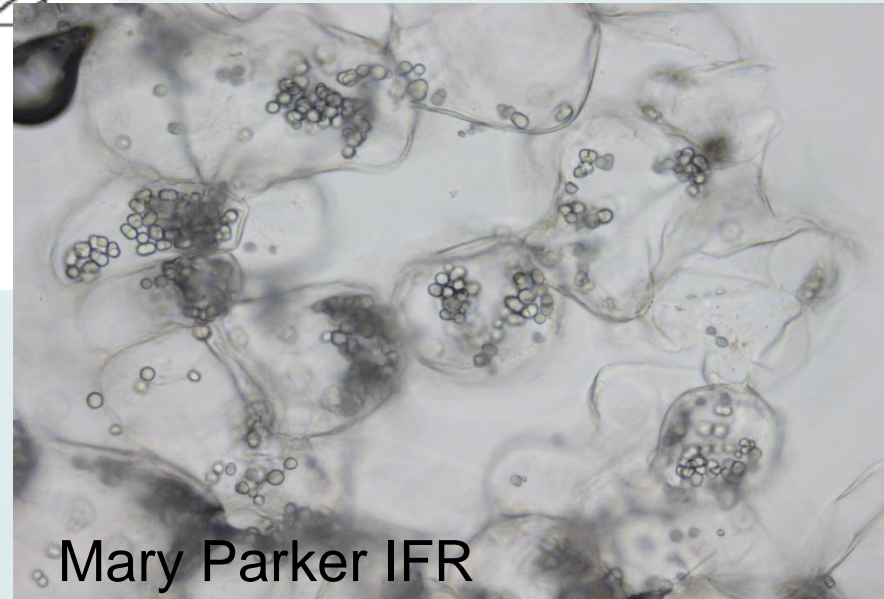
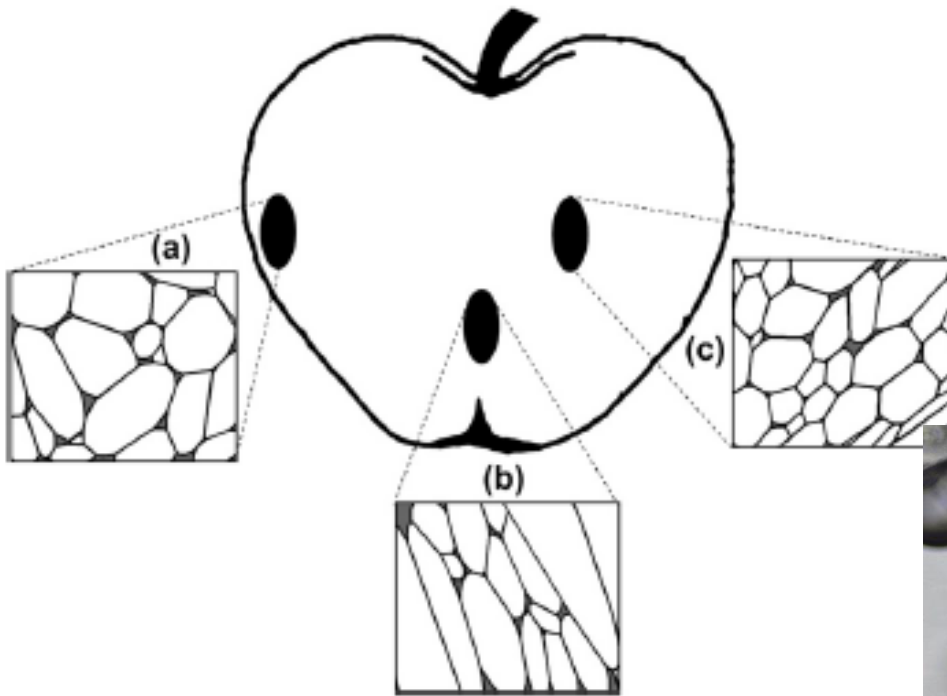


Verboven et al., 2008



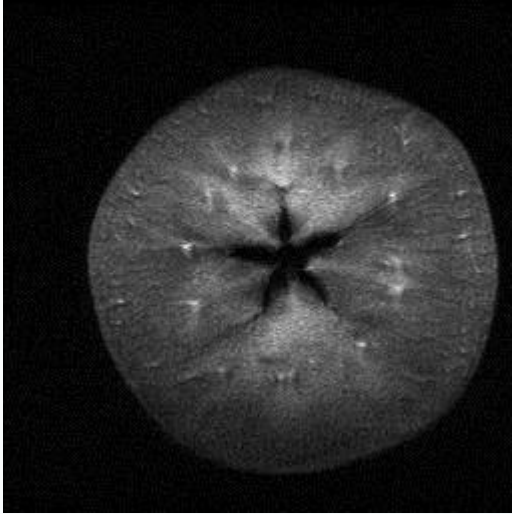
RVE: Representative Volume Element

H.K. Mebatsion et al. / Trends in Food Science & Technology 19 (2008) 59–66

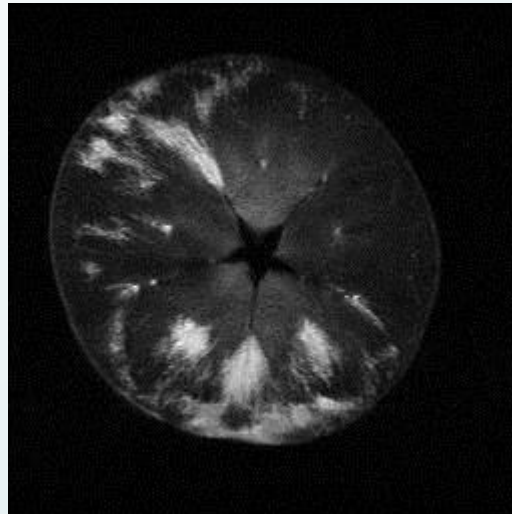


Mary Parker IFR

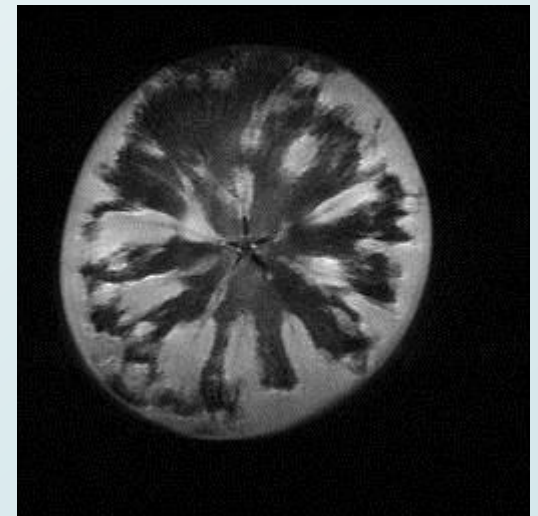
MRI



Sound apple

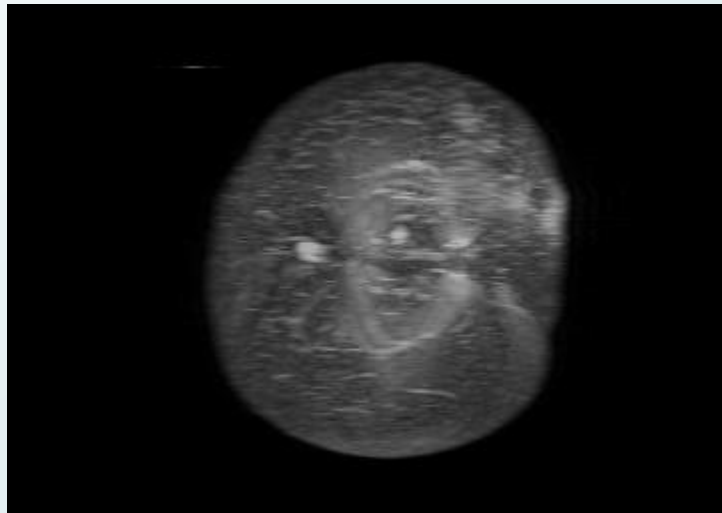
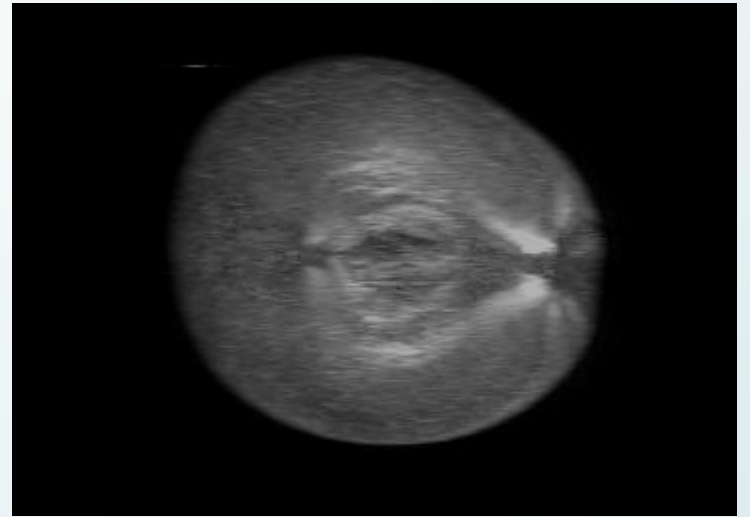
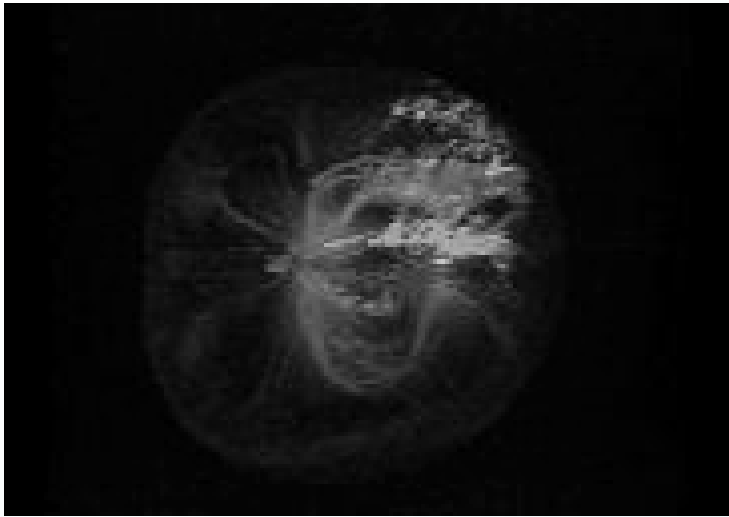


Watercore apple



Watercore apple

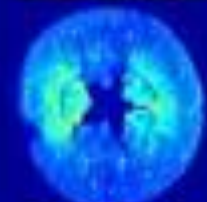
Melado et al., 2010



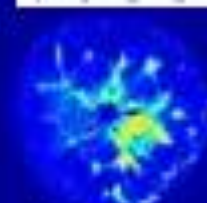
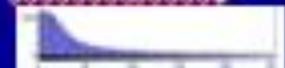
Melado et al., 2011

MRI

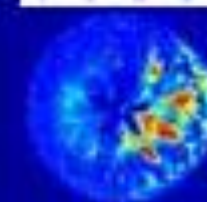
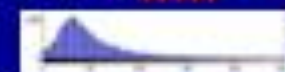
HR-MAS



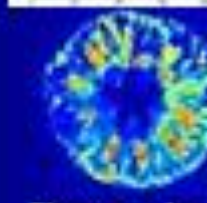
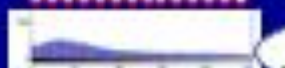
Sound apple
Rebellion variety



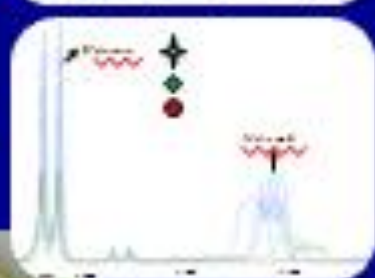
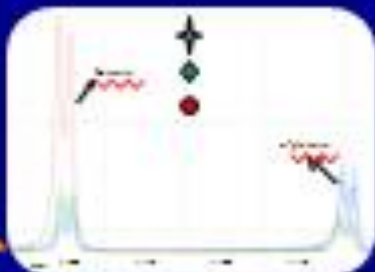
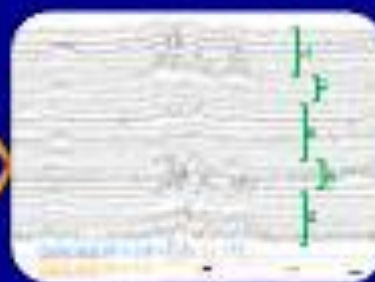
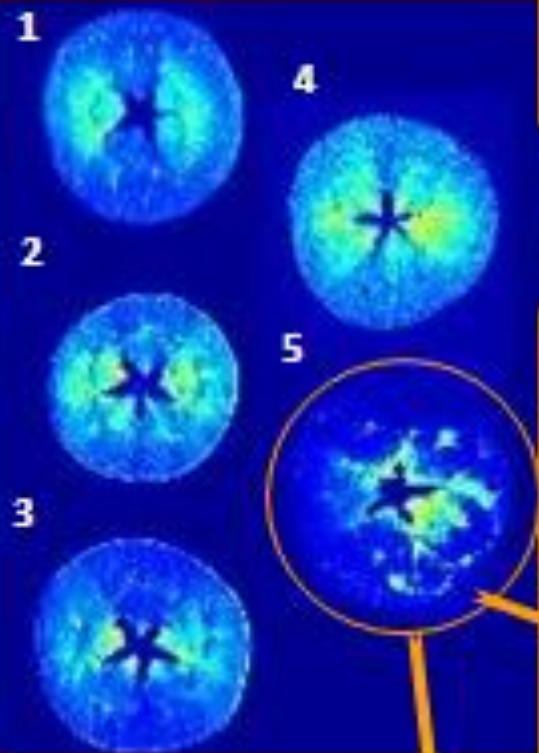
Early stage watercore
Rebellion variety



Light watercore
Rebellion variety



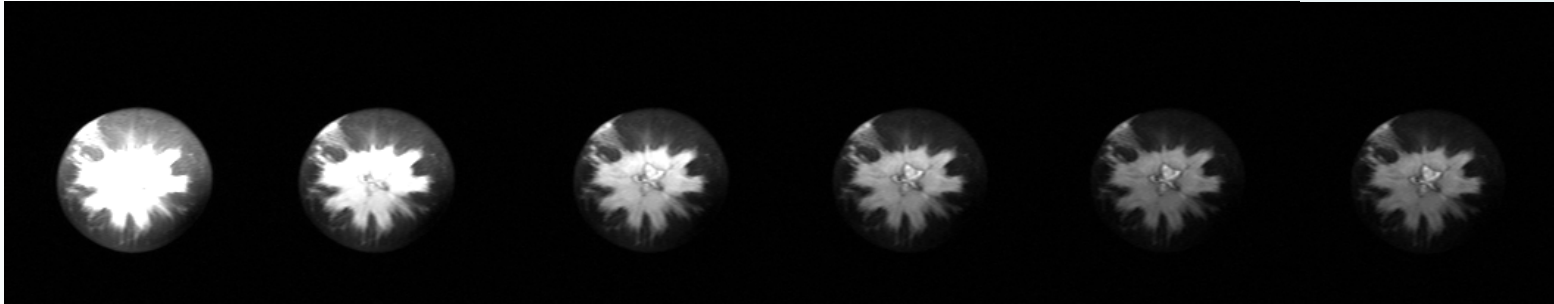
Strong watercore



Melado et al., 2010

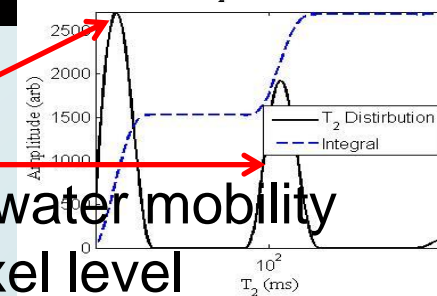
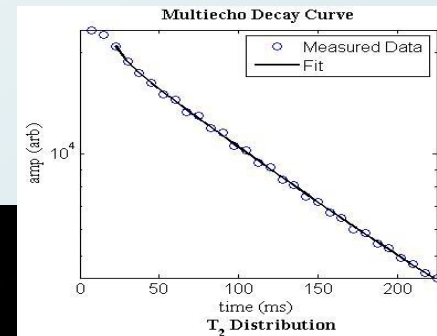
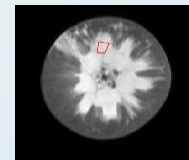
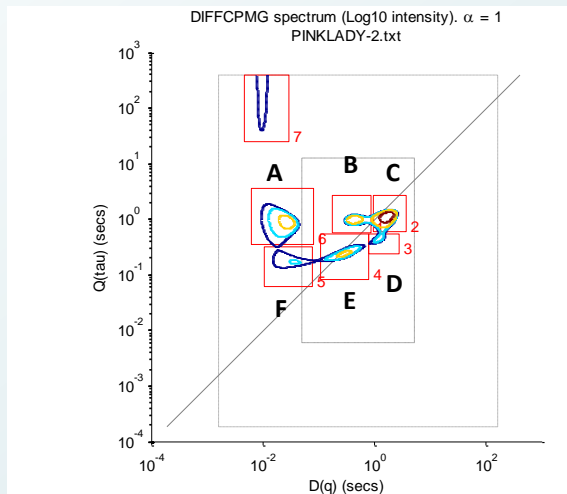
Multi-scale resolution

- MRI {
 - 2D
 - 3D



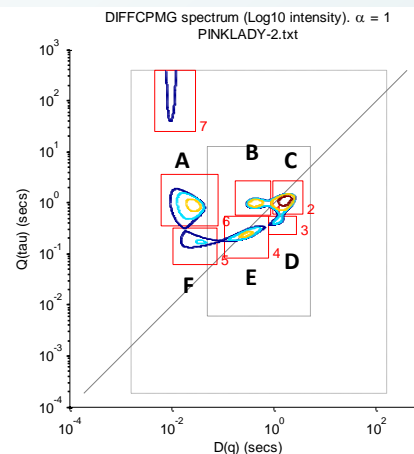
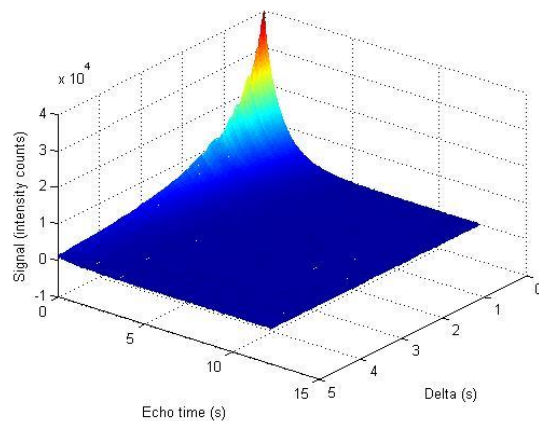
Central slice of a watercore affected apple in a relaxometry sequence, with 6 different echoes.

- Relaxometry {
 - 1D
 - 2D



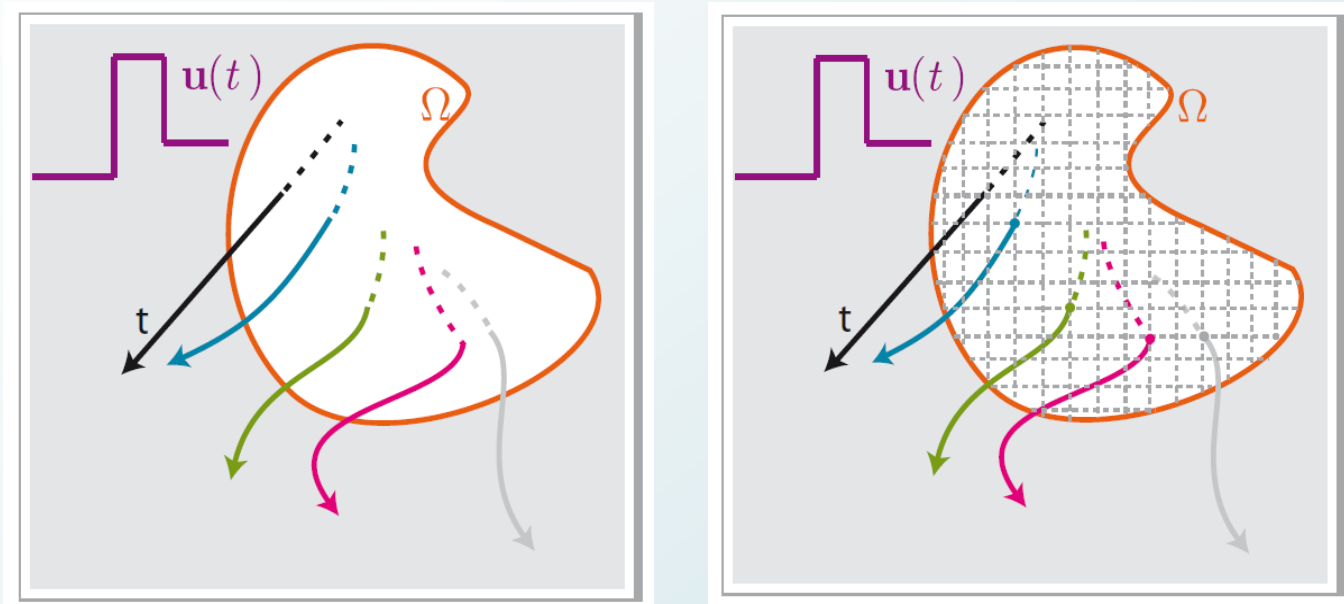
Different water mobility
at sub-pixel level

2D Relaxometry

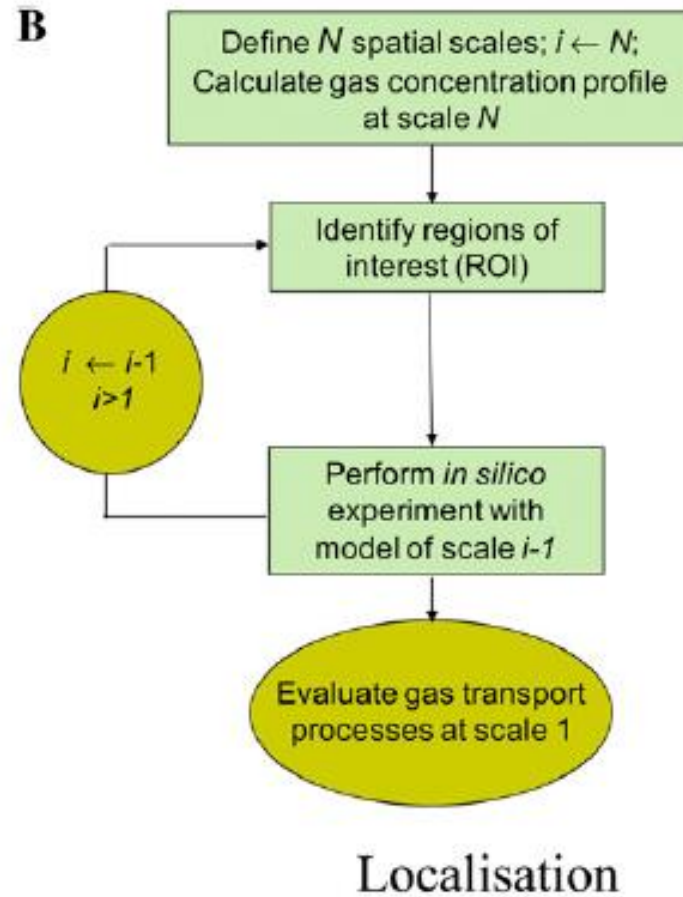
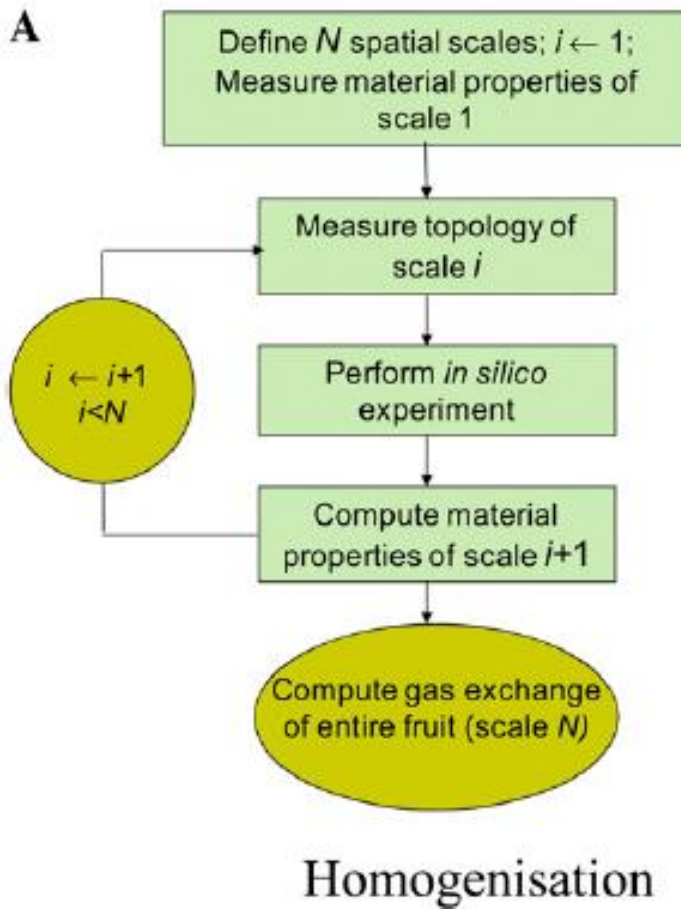


		A	B	C	D	E	F
PKLD1							
T2	Q(tau)	0.9006	0.9867	1.1144	0.4472	0.2433	0.1688
T3	Q(tau)	-	1.0147	1.1089	0.3296	0.1771	-
T5	Q(tau)	-	1.0369	1.2021	-	0.2101	-
PKLD2							
T2	Q(tau)	0.9806	0.9225	1.0746	-	0.2639	0.1775
T3	Q(tau)	0.9842	1.0476	1.0808	-	0.2271	-
T4	Q(tau)	-	1.0113	1.0742	-	0.2167	-
GNNY1							
T2	Q(tau)	1.4882	-	0.8739	0.2871	-	0.1685
T3	Q(tau)	-	0.7803	0.9469	0.3839	0.1889	-
T4	Q(tau)	1.0617	0.8376	0.9714	0.5212	0.2881	-

Spatio-temporal versus temporal modelling



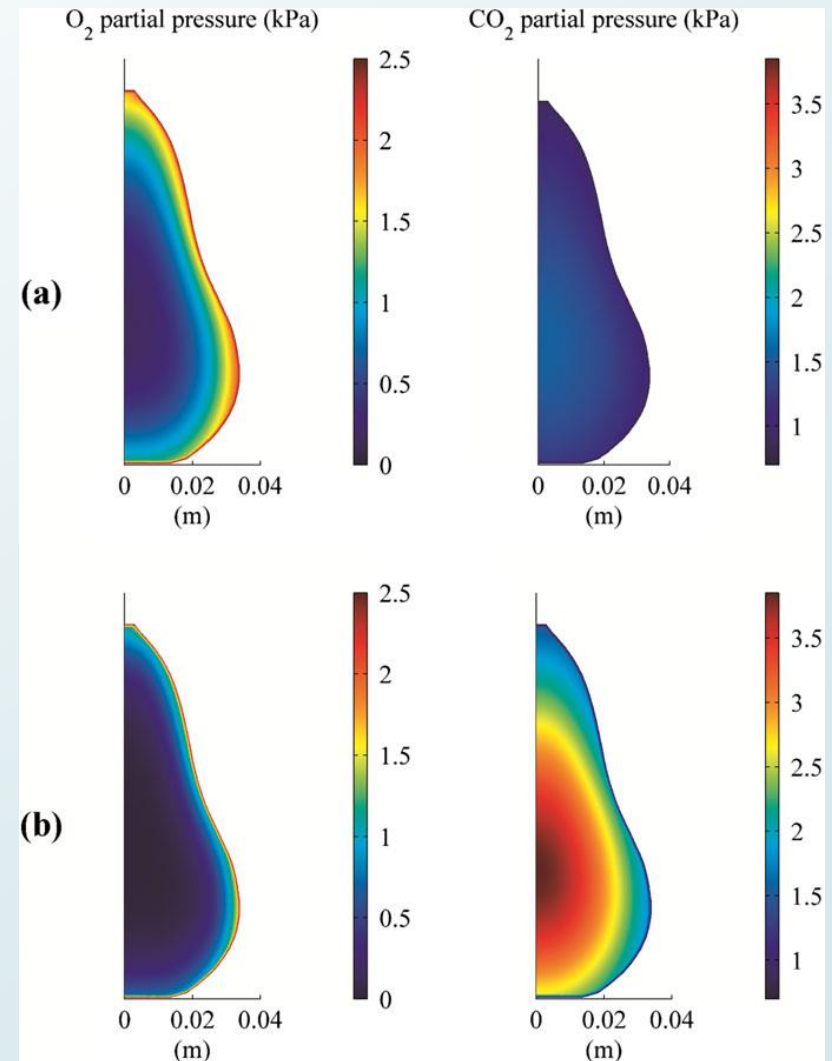
3D Modelling



Spatial modelling: gas diffusion differences



Ho et al. 2010



Conclusion

Current theoretical knowledge, and available modeling tools enable users with limited programming skills to handle complex models, testing ever improved hypothesis. Such framework can also be used for designing new instruments based on modeled response ...

Will you take the challenge?

The Choice

The intellect of (wo)man is forced to choose
perfection of the life, or of the work,
And if it take the second must refuse
A heavenly mansion, raging in the dark.
When all that story's finished, what's the news?
In luck or out the toil has left its mark:
That old perplexity an empty purse,
Or the day's vanity, the night's remorse.

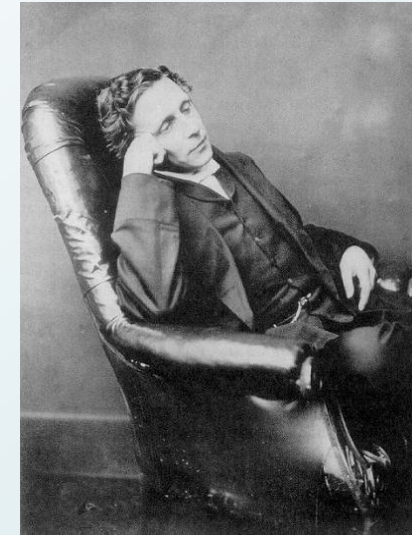
William Butler Yeats





- If this text has given you any useful hints on the important subject of reading, and made you see that it is one's duty no less than one's interest to read, mark, learn and inwardly digest the good books that fall in your way, its purpose will be fulfilled*

Lewis Carroll



Read Broadly,
Think widely